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and radial velocity. A spectrogram of the first star shows numerous metallic lines and a spectral class about G. The second star is classified as A0 in the Henry Draper Catalogue and in consideration of the proper motion and apparent magnitude it is probable that the star is a white dwarf (*loc. cit.*) Two plates obtained in May, 1922, fully confirm the Harvard spectral class and indicate only a small velocity in the line of sight.

November 10, 1922.

WILLEM J. LUYTEN.

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### THE ROTATION PERIOD OF URANUS

In a recent paper Mr. H. Kaul<sup>1</sup> has derived an empirical formula for computing the rotation period of the great planets of our solar system. The formula used is:

$$R^2 = (1 + rK - K) \frac{3}{ra^2}$$

where  $R$  denotes the number of revolutions of a certain planet during one terrestrial day;  $r$  the equatorial radius and  $a$  the mean distance from the Sun; and  $K$  a constant dependent on the inverse of the planet's orbital velocity. The last term enters as an expression for the tidal friction (Gezeitenreibung) caused by the action of the Sun on the planet. As pointed out by Mr. Kaul the formula has a certain analogy with Kepler's third law.

By using values for  $r$  differing only slightly from the values as generally accepted, Mr. Kaul finds a complete agreement between the rotation times for the four great planets for which this quantity is accurately known from observation. The results are, perhaps, best illustrated by the following table, taken partly from Mr. Kaul's paper:

Planet	Rotation Period Observed	Rotation Period Computed	Value for $r$ Used by the Comp.	Value for $r$ Generally Accepted <sup>2</sup>
Mercury	?	imaginary	0.376	0.370
Venus	long period?	26 <sup>h</sup> 28 <sup>m</sup> 53 <sup>s</sup>	0.972	0.966
Earth	23 <sup>h</sup> 56 <sup>m</sup> 4 <sup>s</sup>	23 56 4	1.000	1.000
Mars	24 37 23	24 37 23	0.530	0.540
Jupiter	9 50 0	9 50 0	11.277	11.140
Saturn	10 14 0	10 14 0	9.349	9.400
Uranus	10 50 0	13 45 18	4.000	4.000
Neptune	?	11 4 5	4.300	4.300

<sup>1</sup>Physikalische Zeitschrift, 23, 184, 1922.

<sup>2</sup>Values taken from Annuaire des Bureau des Longitudes, 1922.

As Mr. Kaul states that no direct determination exists of the rotation period of *Uranus*, and as it seems not to be generally recognized that this constant must be considered as known at least approximately we give here a short review of the published facts regarding the rotation of *Uranus*.

In 1904, Dr. Bergstrand<sup>3</sup> published an extensive paper concerning the orbit of the first satellite *Ariel*. He found a secular displacement of the periuranium evidently due to an oblateness of the planet. From that displacement, the oblateness of *Uranus* was computed to be 1/15 and by using that value and Barnard's value for the equatorial diameter of the planet, the rotation period was computed to be eleven hours.

In 1912, Dr. Lowell and Dr. V. M. Slipher<sup>4</sup> published results of a spectroscopic determination of the rotation of *Uranus*. The value,  $10\frac{3}{4}$  hours, was in beautiful agreement with the value first mentioned as derived from entirely theoretical considerations.

Another independent confirmation of the rotation period of *Uranus* was given by the photometric results of Mr. L. Campbell.<sup>5</sup> He found a variation in the brightness of the planet with a period of 10.8 hours, which was considered to be due to the rotation of the planet. As is well known, Müller<sup>6</sup> did not find any variation in his photometric measures in the years 1884-85, and recently Wirtz<sup>7</sup> has published estimates of the brightness of *Uranus*, in which no period depending on the rotation seems to be shown. No discussion of the possible cause of these discrepancies will be undertaken here. It may only be said that the data of Müller and of Wirtz do not disprove the results obtained by Campbell as physical factors other than the rotation may have to be considered in discussing photometric measures of the planets. Thus we have the following determinations of the rotation period of *Uranus*:

Authority	Rotation Period	Method
Bergstrand	11 hours	Perturbation theory
Lowell and Slipher	10 hours 45 <sup>m</sup>	Spectroscopic measures
Campbell	10 hours 50 <sup>m</sup>	Photometric measures

<sup>3</sup>*Nova Acta Reg. Soc. Upsaliensis*, Ser. III. **20**, Fasc 2, 1904.

<sup>4</sup>*Lowell Observatory Bull.*, No. 53, 1912.

<sup>5</sup>*Harvard Observatory Circ.*, No. 200, 1914.

<sup>6</sup>*Potsdam Publ.*, **8**, 197, 1893.

<sup>7</sup>*Astr. Nachr.*, **216**, 437, 1922.

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Of course, each of the three methods is affected by considerable uncertainty and the good agreement may be considered as partly accidental. The first impression will be perhaps, that there is good agreement between the rotation computed from Mr. Kaul's formula and the value actually observed, but the following facts point in another direction.

The value for the equatorial diameter in angular measure generally accepted seems to be 4".00. By inspection of the existing material, one will find a rather wide range in the measured values. The lowest value measured seems to be 2".87 (Main) and the highest 4".45 (Müller). But the more modern and extensive measures shows a better agreement and 23 different series of determinations (containing most of the known material) give the value:

$$r=3''.83$$

It is true that the weighting of the different observations can not be free from personal judgment, and different systems of weighting can be used. Still the bulk of the material seems to suggest that the equatorial diameter of *Uranus* is at least 0".17 smaller than the value used in several ephemerides. Using this smaller value for  $r$ , we find that Dr. Bergstrand's rotation period as well as that of the Flagstaff observers will be *diminished*, but that the value from the empirical formula of Kaul will be *increased*, thus making the difference between observation and calculation still larger than in the table.

It is also to be remembered, as shown by Dr. W. W. Campbell in his memoir concerning the polar diameter of Mars<sup>8</sup> that most of the different sources of error entering into measures of that kind—spherical and chromatic aberration, imperfect atmospheric conditions, irradiation, diffraction and imperfect focus—*tend to increase the measured value of the diameter*. The values used for the diameters of planets may thus generally be somewhat too large and in case of *Uranus* the value derived above may very well be 10% too large.

Thus, it seems that it would be of interest to ascertain whether a redetermination of the constants in Mr. Kaul's interesting formula could, without giving up the agreement already

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<sup>8</sup>A. J., 15, 144, 1895.

found for four planets, yield a better agreement for *Uranus* as well as a good prediction for the rotation period of *Neptune*, which has not yet been determined from direct measures.

Flagstaff, Ariz., Nov. 12, 1922.

KNUT LUNDMARK.

NOTE ON THE RADIAL VELOCITY OF A. G. HELS. 7484

(R. A. 13<sup>h</sup>.9<sup>m</sup>.5, Dec. + 57°14', 6<sup>w</sup>.7, G5)

Attention to this star was called by Hertzsprung, who, on evidence of the proper motion, suspected the star to be a member of the *Ursa Major* stream. The radial velocity computed on the basis of that assumption is —14 km/sec.

Five spectrograms of this star were secured between April 18 and May 12, 1922, two with the Mills three-prism spectrograph and three with a one-prism spectrograph. The resulting radial velocities are —7.9, —5.1 (III pr.) —14, —6, —15 km/sec (I pr.) giving for the weighted mean —8 km/sec. From the plates no evidence can be found for doubling of the lines but the possibility still remains open that the star has a variable velocity.

As especially the three prism velocities differ more from the computed velocity than the permissible error we can as yet not decide whether this star does or does not physically belong to the *Ursa Major* group.

Nov. 10, 1922.

WILLEM J. LUYTEN.

PERSONAL NOTES

On the occasion of the inauguration of Dr. C. R. Richards as President of the Lehigh University, on October 14, honorary degrees were conferred upon some of Lehigh's distinguished alumni. Among these awards was the degree of Doctor of Science to Professor Richard Hawley Tucker (C. E. '79), astronomer in the Lick Observatory, and to William Bowie (C. E. '95), chief of the Division of Geology, U. S. Coast and Geodetic Survey.

<sup>1</sup>B. A. N., 1, 86, 1922.